REQUEST FOR ACTION (RFA)

1. Review Type	2. RFA No.	3. Review Date
TKUP-A Demonstration Requirements Review	278-01	**8/2/06**

4. Title

Early validation of Shuttle functions

5. Action

Suggested minimum prototype test: if Level 0 is implemented in the demo, once vendor selection is made, if prototype will represent production, then flow shuttle from ESTL through TDRS. ESTL can support much more extensive tests in a precision laboratory environment.

Reference

6. Originator/Organization/Telephone No./E-mail

Chatwin Landsdowne ESTL/JSC 281.483.1265 chatwin.landsdowne@nasa.gov

7. Assigned To/Organization/Telephone No./E-mail	Due Date
Franklin Hartman / WSC / 505.527.7363 / fhartman@mail.wsc.nasa.gov	8/10/2006

8. Response

The purpose of the demonstration is to mitigate the most significant risks associated with the project requirements. The only shuttle configuration the TKUP-A receive equipment will be required to support is the KSHR-Mode1, PSK. The project team considers this a very low risk requirement, primarily because the only recovery required is the high-power, channel-3 data; the TKUP-A equipment will not be required to process the lower power, subcarrier channel. Also, to recover the Channel-3 data, the prototype receiver would be required to process the 5-stacked-encoder data. At present, the project is not requiring the vendor to implement the stacked decoders for the demonstration; this is not considered a significant risk and would probably result in non-trivial development costs for this non-standard decoding design.

In addition, the NASA SOW to NENS requires a very short schedule for the demonstration phase. Consequently, the time allowed for each demonstration will probably be limited, limiting the amount of testing the project can conduct with each prototype receiver. Again, because the shuttle mode is considered low risk, demonstration time has not been allocated for coordinated ESTL tests.

When first article tests are performed for the production TKUP-A receiver, it would be highly appropriate to include testing with ESTL to validate this configuration.

9. Response By/Organization/Telephone No./E-mail	Date Prepared
Franklin Hartman / WSC / 505.527.7363 / fhartman@mail.wsc.nasa.gov	8/23/2006

10. Originator Contacted	☐ No	☒ Yes	Date

11. Disposition	☐ Open	☐ Deferred	☒ Closed	☐ Withdrawn

12. Comments

Date: Tue, 5 Sep 2006 11:32:40 -0500
From: "Lansdowne, Chatwin (JSC-EV)" <chatwin.lansdowne-1@nasa.gov>
To: "Franklin Hartman" <fhartman@mail.wsc.nasa.gov>

OK, I agree.

13. Approval

Yen Wong – Product Design Lead

10/18/06
Date

REQUEST FOR ACTION (RFA)

1. Review Type	2. RFA No.	3. Review Date
TKUP-A Demonstration Requirements Review	278-02	**8/2/06**

4. Title

Suitability/collaboration with Deep Space Network

5. Action

Must any additional capabilities be demonstrated (e.g., expanded doppler requirements) to prove this receiver could work for DSN? Constellation wants similar ground stations if possible.

Can this receiver be used in a DSN site?

Can this receiver support DSN commitments (rates/modulation coding) outside the SNUG?

Reference

6. Originator/Organization/Telephone No./E-mail

Chatwin Landsdowne ESTL/JSC 281.483.1265 chatwin.landsdowne@nasa.gov

7. Assigned To/Organization/Telephone No./E-mail	Due Date
David Zillig QSS Group, Inc. 301-286-8078 david.zillig@gsfc.nasa.gov	

8. Response

In discussions with the RFA originator, it was agreed that the primary intent of this RFA was to ensure that the benefits of Ka-Band receive system commonality be explored across the network facilities which will support Constellation flight elements and that any possible economies of scale during new equipment purchases be coordinated to the extent possible between the responsible organizations for the overall benefit of NASA.

See Attached Response

9. Response By/Organization/Telephone No./E-mail	Date Prepared
David Zillig QSS Group, Inc. 301-286-8078 david.zillig@gsfc.nasa.gov	9-18-06

10. Originator Contacted	☐ No	☒ Yes	Date	9-20-06

11. Disposition	☐ Open	☐ Deferred	☒ Closed	☐ Withdrawn

12. Comments

Subject: RE: Draft Response to TKUP-A RFA # 2
Date: Wed, 20 Sep 2006 11:57:55 -0500
From: "Lansdowne, Chatwin \(JSC-EV\)" <chatwin.lansdowne-1@nasa.gov>
To: "David Zillig" david.zillig@gsfc.nasa.gov

The write-up looks like it captures the concern that the prototype needs to keep our options open for expanding our application.

13. Approval

Yen Wong – Product Design Lead

10/18/06
Date

RFA #2 Response

The primary objective of the TKUP-A Project is to replace the HDR Ku-/Ka-Band receive system in the SN which is nearing obsolescence no later than 2009. A secondary objective is to explore the enhancement of the TDRSS 225MHz channel by the addition of new coding and modulation schemes in the replacement equipment to extend the data rates from the current maximum150Mbps, with rate ½ convolution coding to Rate 7/8 coded data rates of over 400Mbps/SQPSK and 600Mbps/8PSK for the benefit of future customers. Optionally, the TKUP-A demonstration phase may also demonstrate data rates at 1Gbps and above through the second generation TDRS' 650MHz Ka-Band channel.

In response to this RFA and RFA 278-09, which advised the TKUP-A Project to ensure that the ECANS project management and chief engineer are consulted on TKUP-A plans, objectives and results, Yen Wong, TKUP-A PDL, and I met with the ECANS staff on September 6, 2006. At the meeting, ECANS representatives expressed interest in adding a power efficient rate ½ (AR4JA) LDPC code to the TKUP-A demonstrations in 2007. Currently, the Cx C3I FEC Coding Study calls for the use of rate ½ LDPC on the Ka-Band R/L at rates below those enabled by the bandwidth efficient rate 7/8 LDPC code being demonstrated to expand the SN maximum data rate capability. As a result of the meeting, TKUP-A is planning to include a rate ½ LDPC code in the demonstration along with the legacy rate ½ convolutional code and the rate 7/8 LDPC and/or rate 7/8 TPC. This is beneficial to TKUP-A since it represents a potential requirement from an important future SN customer and to ECANS since it will provide valuable data on the performance of the new LDPC code through a TDRS satellite. (In addition to ECANS management, the TKUP-A team has recently provided project status updates to the JSC Advanced Avionics Working Group (AAWG), the ECANS Lunar Mission Ground System Study Team and plans to continue close coordination with JSC ESTL planners.)

Since the GSFC NENS contractor, HTSI, plans to award two demonstration phase contracts, this should provide at least two potential bidders for the SN HDR equipment replacement. These vendors may also be potential bidders on equipment for other network facilities providing Ka-Band support to Cx elements.

At this point in time, it is too early to predict whether the functional, performance and interface requirements for the SN replacement HDR receive systems will be sufficiently similar to the other Cx ground support facilities to justify buying identical equipment or if the procurement schedules will allow consolidating the equipment procurement for both the SN and other ground facilities. Close coordination between ECANS planners and the TKUP-A team during the demonstration phase, however, should enable achieving as much commonality as practical, reduce the implementation risk and help create a competitive environment for procurement of Ka-Band receivers for all systems supporting Cx.

REQUEST FOR ACTION (RFA)

1. Review Type	2. RFA No.	3. Review Date
TKUP-A Demonstration Requirements Review	278-03	**8/2/06**

4. Title

I:Q power ratio requirement

5. Action

Consider removal of I:Q power ratio requirement of 4:1

Reference

Slide 24

6. Originator/Organization/Telephone No./E-mail

Ronna Brockdorff ITT 301.486.4269 ronna.brockdorff@itt.com

7. Assigned To/Organization/Telephone No./E-mail	Due Date
Yen Wong Code 567 301.286.7446 yen.f.wong@nasa.gov	

8. Response

The I:Q power ratio of 4:1 was evaluated as a low risk project requirement during the risk assessment process. It will not be a demonstration requirement for the prototype receiver development in the demonstration phase. This issue will be considered during the production phase. Code 450 system engineering will be consulted on the need of this requirement for K-Band service. Results will be incorporated into the to be developed production receiver requirements specification Final decision will be made during the production phase.

9. Response By/Organization/Telephone No./E-mail	Date Prepared
Yen Wong Code 567 301.286.7446 yen.f.wong@nasa.gov	8/23/06

10. Originator Contacted	☐ No	☒ Yes	Date	9/1/06

11. Disposition	☐ Open	☐ Deferred	☒ Closed	☐ Withdrawn

12. Comments

Subject: RE: TKUP-A DRR RFA #3 Response
Date: Fri, 1 Sep 2006 10:50:20 -0400
From: "Brockdorff, Ronna -AES" <Ronna.Brockdorff@itt.com>
To: "Yen F Wong" <yen.f.wong@nasa.gov>
Cc: "Franklin Hartman" <fhartman@mail.wsc.nasa.gov>

I have no problem with this response. Just keep me in the loop in the future. Thanks.

13. Approval

Yen Wong – Product Design Lead

10/18/06
Date

REQUEST FOR ACTION (RFA)

1. Review Type	2. RFA No.	3. Review Date
TKUP-A Demonstration Requirements Review	278-04	**8/2/06**

4. Title

Single data channel QPSK

5. Action

Ensure level 0 requirements include JEM requirements for single data channel QPSK.

Does this requirement have and increased risk associated with channel ambiguity resolution to recombine single data channel requiring additional testing?

Reference

Slide 22-23

6. Originator/Organization/Telephone No./E-mail

Ronna Brockdorff ITT 301.486.4269 ronna.brockdorff@itt.com

7. Assigned To/Organization/Telephone No./E-mail	Due Date
John Wesdock/ITT/703.668.6332/ John.Wesdock@itt.com	9/29/06

8. Response

See attachment response.

9. Response By/Organization/Telephone No./E-mail	Date Prepared
John Wesdock/ITT/703.668.6332/ John.Wesdock@itt.com	

10. Originator Contacted	☐ No	☒ Yes	Date	9/11/06

11. Disposition	☐ Open	☐ Deferred	☒ Closed	☐ Withdrawn

12. Comments

Subject: RE: TKUP-A DRR RFA #4 and #5 Draft Responses
Date: Mon, 11 Sep 2006 08:26:41 -0400
From: "Brockdorff, Ronna -AES" <Ronna.Brockdorff@itt.com>
To: "Wesdock, John -AES" <John.Wesdock@itt.com>
Cc: <yen.f.wong@nasa.gov>, "Tran, Leonardi -AES" <Leonardi.Tran@itt.com>,
<fhartman@mail.wsc.nasa.gov>, <Wai.H.Fong@nasa.gov>

John,

Looks good to me. Thanks for the consideration of increasing the rate even if it was beyond the intent of the original RFA.

Ronna

13. Approval

Yen Wong – Product Design Lead

10/18/06
Date

RFA #4 Resolution

Section 4.2.2.2.b of the *Radio Frequency Interface Control Document Between the Japanese Experimental Module (JEM) and the Space Network (SN)* [1] indicates the JEM NRZ-M converts a 50 Mbps return service NRZ-L data stream, rate 1/2 convolutionally encodes it, and then alternates the encoded symbols onto the I and Q channel of a 1:1 QPSK modulator. The following figure illustrates these JEM return service operations:

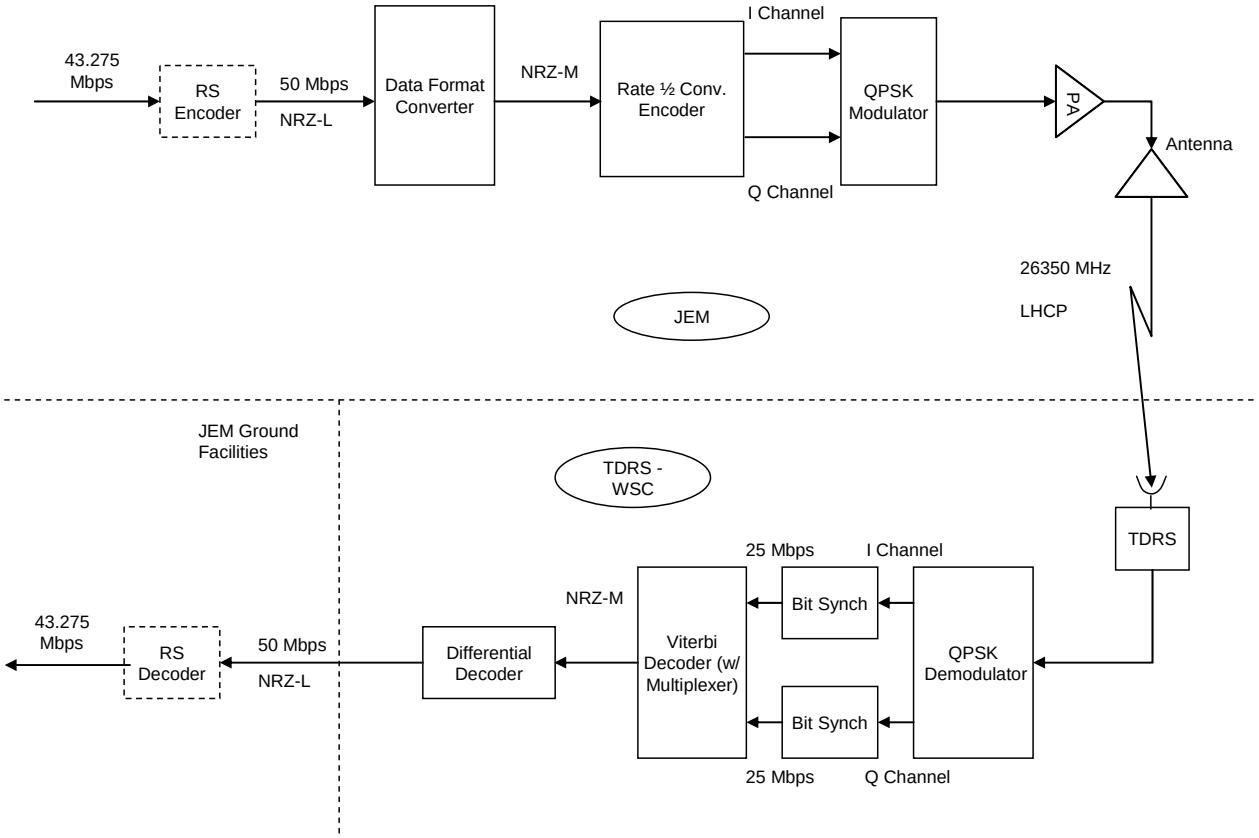


Figure 1. JEM-to-TDRS KaSA Return Link Configuration

The TKUP Requirements Specification (RS) includes support for the JEM return service configuration per the following sections and excerpts:

- Table 3-1: Rate ½ convolutional coding, single channel QPSK supported data rates: 4 Mbps – 75 Mbps. Same symbol rates on I-channel and Q-channel channel, but using alternate I/Q Encoded Symbols only. It is noted in Table 3-1 that the 75 Mbps maximum supported single channel data rate (i.e., total data rate = I+Q) was selected based upon the capability of commercially-available Viterbi decoder devices.

- Table 4-5, row c3 and note 4: Rate ½ Convolutional Coding, Single Channel at 4 Mbps - 75 Mbps. Single channel QPSK with same symbol rates on I-channel and Q-channel channel, but using alternate I/Q Encoded Symbols only. It is again noted in Table 4-5 that the 75 Mbps

maximum supported single channel data rate (i.e., total data rate = I+Q) was selected based upon the capability of commercially-available Viterbi decoder devices.

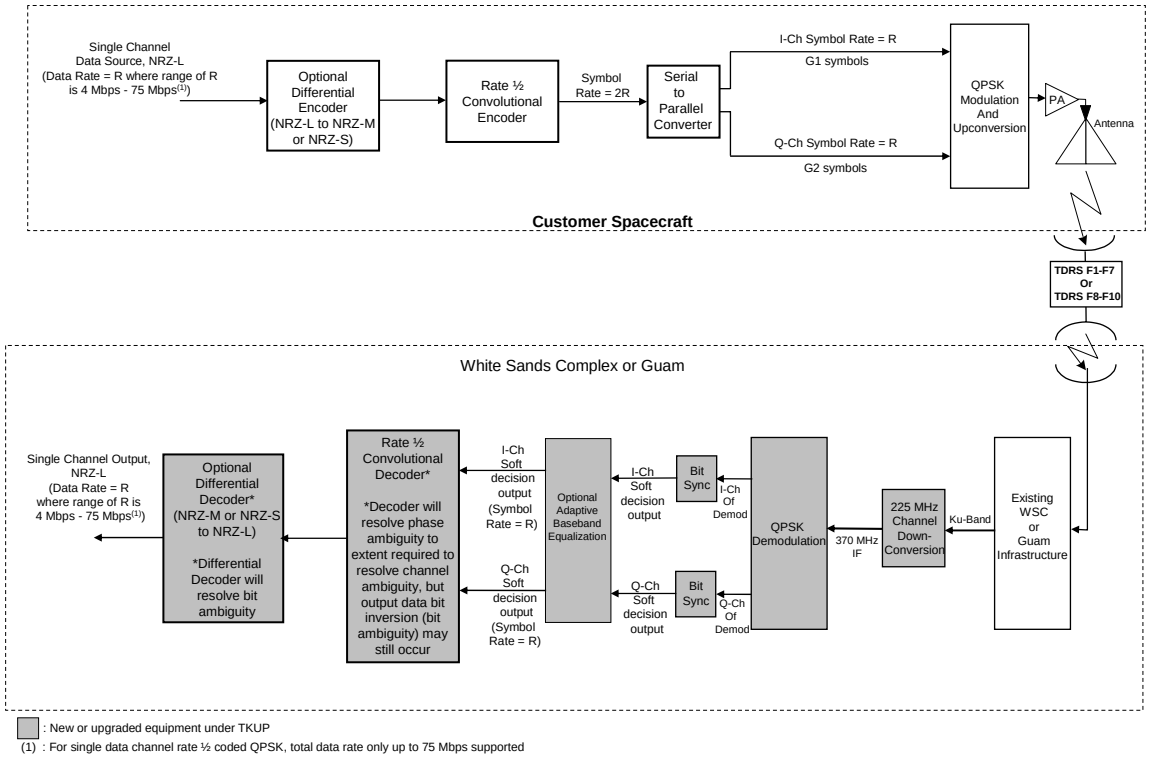
- Section 4.3.2.b.6: Rate ½ Coded QPSK, Single Channel Configuration (Alternate I/Q Symbols):
  a. Support alternate I/Q encoded symbols without multiple encoders in parallel (encoder stacking).
  b. Support G1 symbols on I-channel and G2 symbols on Q-channel.

- Table 4-6, row 1 and note 2: Single data channel convolutional coding supported. For QPSK, only the "alternate encoded symbols" method is used for single channel operations.

- Section 4.3.7.1.e.5: 5. G2 Inversion: Symbols generated from G2 shall be either true or complemented

- Section 4.3.7.1.2: Single Channel QPSK and SQPSK (4 Mbps to 75 Mbps) (Alternate I/Q Symbols): Only a single encoder shall be used when using alternate I/Q symbols with QPSK and SQPSK.

- Figure C-6: See diagram below:



Each of these requirements are categorized as Level 0 requirements in the TKUP-A Project Requirements Matrix.

Worthy of discussion at this point is whether to modify the TKUP-A requirements to support single channel QPSK and SQPSK (alternate I/Q symbols) up to 150 Mb/sec, beyond the 75 Mb/sec currently required to be supported. As of early 2005, commercially-available Viterbi decoder chips were capable of supporting data rates up to about 75 Mb/sec. A brief market search in response to

this RFA indicates at the very least Viterbi decoder FPGA cores exist which support data rates up to 185 Mb/sec. Considering the availability of these cores and the distant receiver delivery date, it is recommended that the TKUP-A requirements be modified to require support of data rates up to 150 Mb/sec for single channel QPSK and SQPSK (alternate I/Q symbols).

It is recommended that the TKUP-A demonstration plan not be modified to include demonstration of single channel QPSK or SQPSK (alternate I/Q symbols) at 150 Mb/sec. While there certainly may be risk associated with such a configuration which a demonstration could mitigate, the TKUP-A project should not be the project to fund the development of such a device considering how arbitrary the need is for a 150 Mb/sec single channel QPSK or SQPSK (alternate I/Q symbols) service mode.

Moving back to the original intent of the RFA, channel and bit ambiguity resolution for the single channel QPSK service mode are addressed in the following sections of the TKUP RS:

- Section 4.3.8.1.f: For Rate ½ Coded QPSK, Single Channel Configuration (Alternate I/Q Symbols), data bit ambiguity will be resolved using Non-Return to Zero-Mark (NRZ-M) or Non-Return to Zero-Space (NRZ-S).

- Section 4.3.8.2.f: For Coded Single Channel QPSK, Channel ambiguity shall be resolved.

The TKUP RS does not state a required manner for resolving the channel ambiguity, however, it is expected that the implementation contractor will use the Viterbi decoder to resolve the ambiguity. Channel ambiguity resolution is possible with the Viterbi decoder as incorrect assignment of G1 to G2 symbols and G2 to G1 symbols by the Viterbi decoder will result in a continual inability to achieve or maintain decoder lock, assuming pattern data is not present. For additional discussion on this topic please consult the *ATV Bit Transition Density Requirement Justification* memo which is attached to this RFA response.

To determine whether the single channel rate ½ coded QPSK communications mode holds sufficient risk to mandate that it be included in the demonstration, an approach must be formulated for how the decoder would resolve the channel ambiguity. The most likely manner in which the decoder would resolve channel ambiguity would be as follows:

1. Make an assignment of G1 and G2 symbols.

2. Mandate that decoder lock occur rapidly (perhaps several tens of thousands of symbols) and that lock be maintained for some reasonable duration (perhaps several tens of thousands of symbols).

3. If decoder lock or continued decoder lock does not occur, the decoder will make a reassignment of G1 and G2. By reassigning G1 and G2, the decoder is essentially re-ordering the input symbols.

Note that channel ambiguity can be resolved with no feedback to the carrier tracking loop or bumping of the carrier tracking loop. Based upon the above envisioned channel ambiguity approach, it is felt that there is not sufficient risk to service mode to warrant inclusion in the TKUP-A demonstration.

References:

[1] *Radio Frequency Interface Control Document Between the Japanese Experimental Module (JEM) and the Space Network (SN)*, 451-RFICD-JEM/SN, NASA/GSFC, October 2005.

Advanced Engineering & Sciences

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GSA-811
30 October 2003

TO: Frank Stocklin/Code 451

FROM: John Wesdock, Leonardi Tran

SUBJECT: ATV Bit Transition Density Requirement Justification

REFERENCES:

[1] Space Network User's Guide (SNUG), Revision 8, 530-SNUG, NASA/GSFC, June 2002.

SUMMARY

The ATV Project has recently requested NASA provide information to substantiate the need for the decoder acquisition bit transition density requirement specified in the Space Network User's Guide [1]. The ATV mission is a TDRSS SSA DG1 customer which means it will use convolutional coding. For coded service, the SNUG specifies both a symbol transition density requirement and a bit transition density requirement. The symbol transition density requirement ensures that the symbol synchronizers can achieve lock within the required time limit. The bit transition density ensures that the Viterbi decoder can achieve lock and properly resolve the G1 G2 ambiguity within the required time limit. This memo examines the rationale for the data bit transition density requirement and demonstrates why the requirement is necessary.

Figure 1 provides an overview of the data and symbol streams at various points in the TDRSS system for the case when the data bit transition density requirement is met. It can be seen from the figure that the following are true:

1. If the decoder makes the correct assignment of G1 and G2, the correct codeword will enter the Viterbi decoder. In this case, the decoder trellis metrics will become indicative of a decoder in lock and the correct data will emerge from the decoder.

2. If the decoder makes the incorrect assignment of G1 and G2, an invalid codeword will enter the Viterbi decoder. In this case, the decoder trellis metrics will be continually indicative of a decoder which is out of lock and incorrect data will emerge from the decoder. **Note that incorrect assignment of G1 and G2 by the decoder does not result in the inverse of the original codeword (which is a valid codeword due to the transparent property of the code) at the trellis input but rather the inverse of the original codeword shifted by one symbol (which is not a valid codeword) at the trellis input**.

In this example, the data bit transition density was sufficient to produce a fully invalid codeword at the trellis input when the incorrect G1G2 assignment was made by the decoder. To demonstrate the need for the data bit transition density requirement, it is necessary to look at a similar graphic for the case of no data bit transitions. Figure 2 provides this graphic. It can be seen from the graphic that the following are true:

1. If the decoder makes the correct assignment of G1 and G2, the correct codeword will enter the Viterbi decoder. The decoder trellis metrics will become indicative of a decoder in lock and the correct data will emerge from the decoder.

2. If the decoder makes the incorrect assignment of G1 and G2, a valid, albeit incorrect, codeword will enter the Viterbi decoder. In this case, the decoder trellis metrics will become indicative of a decoder in lock, however, incorrect data will emerge from the decoder.

Due to the lack of data bit transitions in this example, the decoder will be unable to resolve the G1G2 ambiguity. As shown in Figure 1, however, when an appropriate number of data bit transitions occur, the decoder will clearly be able to resolve the G1G2 ambiguity.

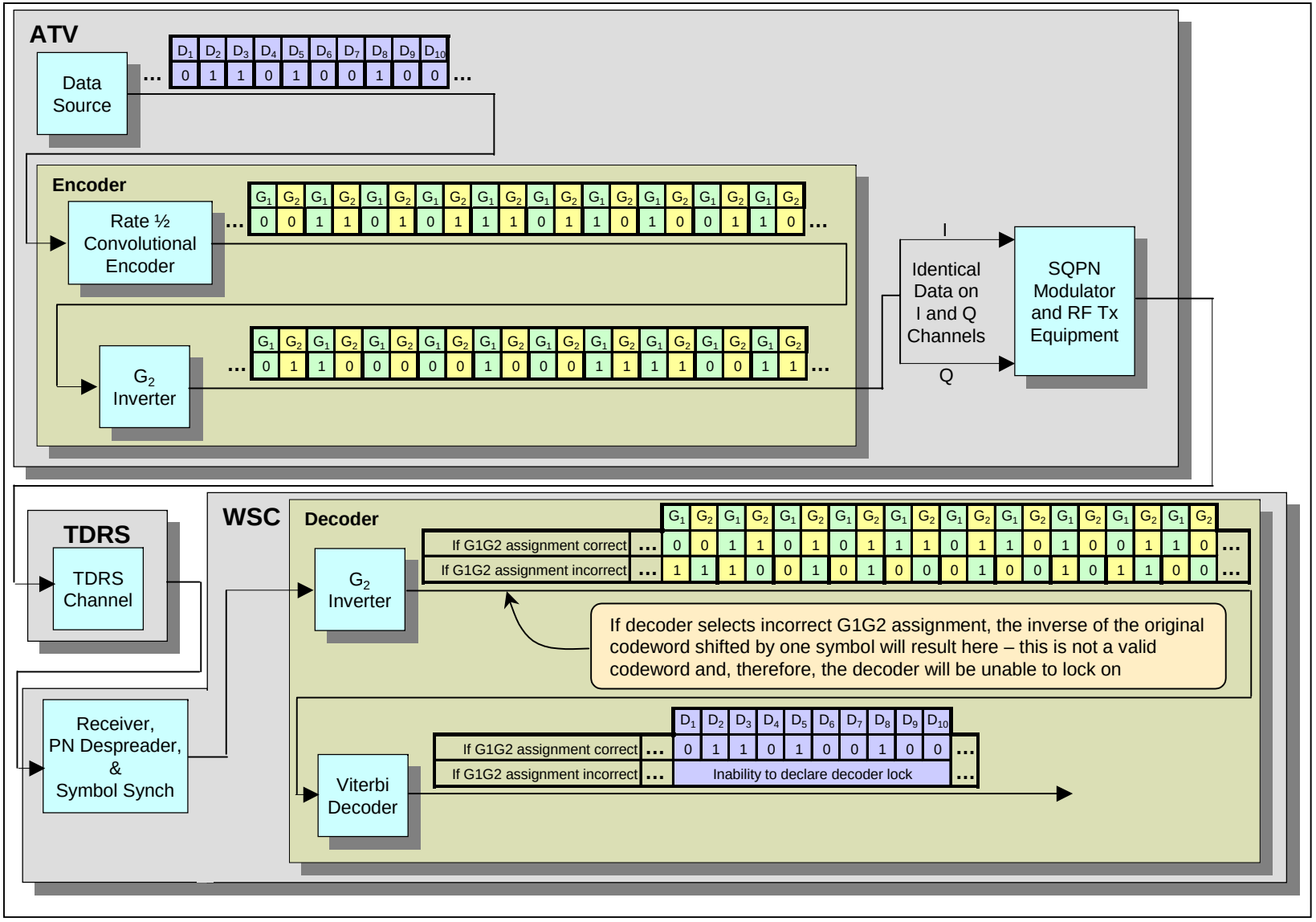

Figure 1. Overview of Data and Symbol Streams when the Data Bit Transition Density Requirement Is Met

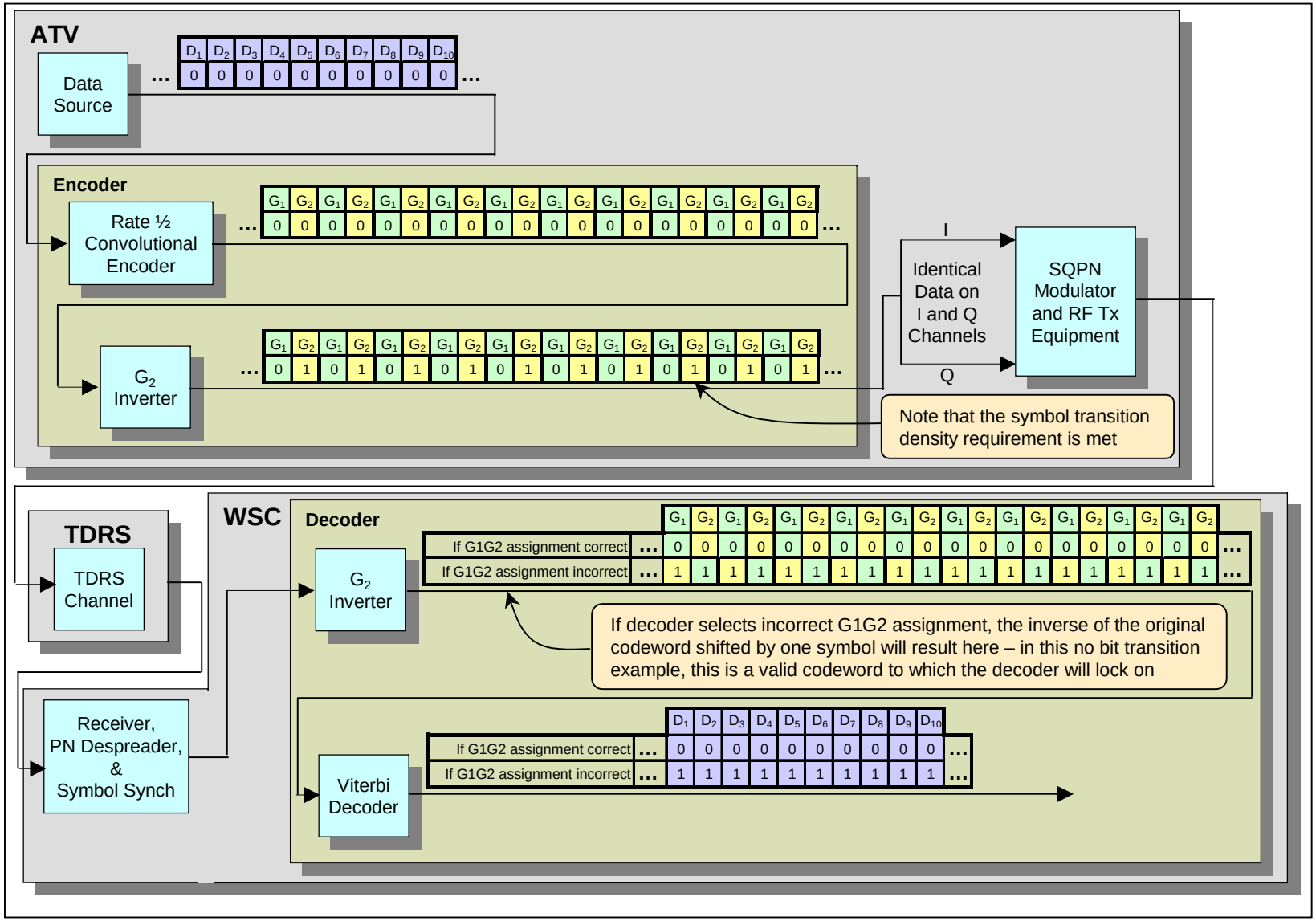

Figure 2. Overview of Data and Symbol Streams when the Data Bit Transition Density Requirement Is Not Met

REQUEST FOR ACTION (RFA)

1. Review Type	2. RFA No.	3. Review Date
TKUP-A Demonstration Requirements Review	278-05	**8/2/06**

4. Title

Total frequency uncertainty

5. Action

Do the requirements for total frequency uncertainty allw for full normal and powered flight (if applicable) dynamics at both KU and KA band?

Ka vehicle dynamics were previously limited due to existing Ku HDRR capabilities.

Consider CEV requirements/ Chatwin to provide links, etc.

Reference

Slide 41-46

6. Originator/Organization/Telephone No./E-mail

Ronna Brockdorff ITT 301.486.4269 ronna.brockdorff@itt.com
Chatwin Landsdowne ESTL/JSC 281.483.1265 chatwin.landsdowne@nasa.gov

7. Assigned To/Organization/Telephone No./E-mail	Due Date
John Wesdock/ITT/703.668.6332/ John.Wesdock@itt.com	9/29/06

8. Response

See attached response.

9. Response By/Organization/Telephone No./E-mail	Date Prepared
John Wesdock/ITT/703.668.6332/ John.Wesdock@itt.com	

10. Originator Contacted	☐ No	☒ Yes	Date	9/11/06

11. Disposition	☐ Open	☐ Deferred	☒ Closed	☐ Withdrawn

12. Comments

Subject: RE: TKUP-A DRR RFA #4 and #5 Draft Responses
Date: Mon, 11 Sep 2006 08:26:41 -0400
From: "Brockdorff, Ronna -AES" <Ronna.Brockdorff@itt.com>
To: "Wesdock, John -AES" <John.Wesdock@itt.com>
Cc: <yen.f.wong@nasa.gov>, "Tran, Leonardi -AES" <Leonardi.Tran@itt.com>,
<fhartman@mail.wsc.nasa.gov>, <Wai.H.Fong@nasa.gov>

John,

Looks good to me. Thanks for the consideration of increasing the rate even if it was beyond the intent of the original RFA.

Ronna

13. Approval

Yen Wong – Product Design Lead

10/18/06
Date

RFA #5 Resolution

This RFA response is organized as follows:

- Section 1 – DRR Corrections and Clarifications
- Section 2 – Proposed RFA Resolution
- Section 3 – Justification
- Section 4 – References

1.0 DRR Corrections and Clarifications

The Demonstration Requirements Review (DRR) briefing provided insufficient detail when describing the receiver acquisition time and range requirements as follows:

> - The receiver acquisition time requirements shall be:
>   - Normal frequency uncertainty (21 kHz): ≤ 1 second
>   - Expanded frequency uncertainty (54 kHz): ≤ 3 second

The DRR briefing intended to convey the material as follows:

> - The receiver acquisition time requirements shall be:
>   - Normal customer oscillator frequency uncertainty* (±21 kHz): ≤ 1 second
>   - Expanded customer oscillator frequency uncertainty* (±54 kHz): ≤ 3 second
>
> *Where customer oscillator frequency uncertainty is defined as the frequency uncertainty relative to the last measured or predicted customer oscillator frequency

Additionally, the DRR briefing incorrectly stated the worst-case supported orbital dynamics as follows:

> - Worst-case dynamics:
>   - Doppler: ±730 kHz (velocity ≤ 7.9 km/s at 27.48 GHz)
>   - Doppler rate: ±1.1 kHz/s (accel ≤ 11.4 m/s^2 at 27.48 GHz)
>   - Doppler accel: ±1.2 Hz/s^2 (jerk ≤ 0.013 m/s^3 at 27.48 GHz)

It was intended that the DRR state the following worst-case supported orbital dynamics:

Velocity: ≤ 12.0 km/s, resulting in Doppler as follows:

- Ku-Band: ≤ ±1.2 MHz at 15.0034 GHz (2-way Doppler).
- Ka-Band: ≤ ±1.1 MHz at 27.48 GHz (1-way Doppler).

Acceleration: ≤ 15 m/s^2, resulting in Doppler rate as follows:

- Ku-Band: ≤ ±1.5 kHz/s at 15.0034 GHz (2-way Doppler).
- Ka-Band: ≤ ±1.4 kHz/s at 27.48 GHz (1-way Doppler).

Doppler acceleration: ≤ 0.02 m/s^3, resulting in Doppler acceleration as follows:

- Ku-Band: ≤ ±2.0 Hz/s^2 at 15.0034 GHz (2-way Doppler).
- Ka-Band: ≤ ±1.8 Hz/s^2 at 27.48 GHz (1-way Doppler).
- Ku-Band during TDRS Maneuvers (Periods of 50 msec maximum, duration spaced at least 1 second apart): ≤ ±30.0 $Hz/s^{2.}$
- Ka-Band during TDRS Maneuvers (Periods of 50 msec maximum, duration spaced at least 1 second apart): ≤ ±55.0 $Hz/s^{2.}$

The correct orbital dynamics stated above are directly traceable to the existing TKUP Requirements Specification document.

2.0 Proposed RFA Resolution

Having stated these corrections and clarifications, the RFA resolution can be proposed as follows:

- Expand the allowable customer oscillator frequency uncertainty to ±55 kHz for all service modes supported by the TKUP-A receiver.
- Maintain the use of the corrected orbital dynamics stated above.
- Expand the allowable customer ephemeris uncertainty from ±2 sec to ±4.5 sec for Ka-band service. Note that a 4.5 sec customer ephemeris uncertainty is already required to be supported for Ku-band service.

3.0 Justification

Justification for the proposed resolution approach is provided in the following sections.

3.1 Customer Oscillator Frequency Uncertainty

RFA 006 from the April 2005 TKUP SRR dealt with the topic of expanding the customer frequency uncertainty beyond the then specified ±21 kHz limit. The accepted response to RFA 006 stated that a normalized customer oscillator frequency uncertainty up to ±2 ppm could be expected. The RFA 006 response went on to state that this normalized uncertainty translated to a customer oscillator

frequency uncertainty of ≤ ±54 kHz. Unfortunately the RFA 006 response did not use the maximum allowed TDRSS KaSAR customer center frequency of 27.48 GHz in the calculations. When a 27.48 GHz center frequency is assumed, it can be shown that a ±2 ppm normalized limit translates to a ±55 kHz customer oscillator frequency uncertainty limit. For this reason, it is proposed in this TKUP-A DRR RFA response that a ±55 kHz customer oscillator frequency uncertainty limit be used in the demonstration requirements and the TKUP-A project requirements. Of additional note is that this ±55 kHz range is available for all service modes supported by the TKUP-A receiver.

Based upon preliminary information provided by CEV project representatives [1], it is expected that the CEV transmitter will meet a ±55 kHz customer oscillator frequency uncertainty requirement.

3.2 Orbital Dynamics

Consulting the NASA Space Network User's Guide (SNUG), it can be seen that the TKUP-A demonstration requirements allow support for orbital dynamics which are equal to the SNUG KuSAR worst-case allowed orbital dynamics and are greater than the SNUG KaSAR worst-case allowed orbital dynamics. Without distinguishing between powered-flight and non-powered flight, it can be concluded that the TKUP-A requirements ensure support of all KuSAR customers currently allowed by the SNUG and an even wider pool of potential Ka-band customers than the SNUG currently allows. Note that the existing SNUG Ka-band orbital dynamic limits already enable support of free-flight customers in circular orbits at altitudes of 125 km and greater with inclinations of up to 98.2º [2].

Regarding the CEV, estimates have been provided for the worst-case orbital dynamics during potential TDRSS contact periods [3]. These worst-case dynamics are as follows:

- Velocity: ≤ 10.8273 km/s
- Acceleration: ≤ 8.8965 m/s^2
- Jerk: ≤ 0.014468 m/s^3

It can be seen that these orbital dynamics are within the limits stated in the corrected DRR text.

3.3 Customer Ephemeris Uncertainty

The SNUG currently requires the customer epoch uncertainty be ≤ ±2 seconds for Ka-band customers. This ±2 sec value is traceable to a 2001 Ka-band Transition Product (KaTP) SRR RFA response document [2] which considered comments provided by the FDF as well as the constraints of the existing High Data Rate Receiver (HDRR) equipment. Considering that the TKUP-A receiver will be a new receiver and that JEM may not be able to ensure a customer ephemeris uncertainty ≤ ±2 sec, the TKUP-A project has concluded that support of up to a ±4.5 sec ephemeris uncertainty for all Ka-band services is a worthwhile, risk-reducing approach.

Based upon this new ephemeris uncertainty and an assumed customer center frequency of 27.48 GHz, a maximum Doppler uncertainty of ±6.183 kHz is expected. This ±6.183 kHz Doppler

uncertainty combined with the customer oscillator frequency uncertainty of ±55 kHz yields a total frequency uncertainty which must be resolved by the TKUP-A receiver of ±61.2 kHz.

To ensure that this requirement modification as well as the modest customer frequency uncertainty requirement modification discussed earlier in this RFA resolution do not place unrealistic demands on the carrier acquisition process, computations similar to those performed for the TKUP project were performed for this new TKUP-A total frequency uncertainty requirement. The result of these updated computations revealed that reliable carrier acquisition would be expected for all TKUP-A-supported signal structures and expected C/No levels. It is noteworthy, however, that carrier acquisition techniques more advanced than a simple wide carrier tracking loop acquisition bandwidth may be required for 8PSK at the lowest supported data rates.

4.0 References

[1] Email from Chatwin Lansdowne of NASA/JSC to Frank Hartman, et al, dated 5 September 2006 with a Subject "Re: Vehicle dynamics analysis."

[2] *Input to KaTP SDR RFA #7, Ka-Band Dynamics Study Follow-Up, Revision 1*, CSOC-GM55-128, Mark Burns, ITT Industries, 20 February 2001.

[3] Email from Chatwin Lansdowne of NASA/JSC to Dave Zillig of QSS (representing NASA) dated 30 August 2006 with a Subject "FW: Vehicle dynamics analysis."

REQUEST FOR ACTION (RFA)

1. Review Type	2. RFA No.	3. Review Date
TKUP-A Demonstration Requirements Review	278-06	**8/2/06**

4. Title

Vendor recovered data recording and preparation for vendor comments/concerns

5. Action

Will the vendor-recovered data be recorded for later review?

How will the TKUP-A team address potential vendor concerns/criticisms which arise during the demo (e.g., TDRS does not meet fidelity requirements stated in demo RFP, etc.)?

Reference

6. Originator/Organization/Telephone No./E-mail

Keiji Tasaki GSFC/452 301.286.9370 keiji.k.tasaki@nasa.gov

7. Assigned To/Organization/Telephone No./E-mail	*Due Date*
Franklin Hartman / WSC / 505.527.7363 / fhartman@mail.wsc.nasa.gov	8/10/2006

8. Response

The TKUP-A NASA-contractor team at this time does not plan to provide for recording of customer data during the demonstrations. It is not certain that recording the receiver data output, post decoder, would provide insight into the root cause of unexpected implementation loss, and to do so would require test equipment and infrastructure that WSC does not currently have. It would also necessitate defining and requiring another interface that the supplier demonstration equipment would have to provide, which would potentially impact supplier NRE expenditures.

The risk that a supplier will be “surprised” by performance through the TDRS channel is being mitigated by providing each demonstration contractor with the opportunity to visit White Sands and perform preliminary tests through the TDRS well in advance of the scheduled demonstrations. The RFP not only invites suppliers to take advantage of this opportunity, but strongly encourages them to do so.

9. Response By/Organization/Telephone No./E-mail	*Date Prepared*
Franklin Hartman / WSC / 505.527.7363 / fhartman@mail.wsc.nasa.gov	8/23/2006

10. Originator Contacted	☐ No	☒ Yes	Date	9/1/06
11. Disposition	☐ Open	☐ Deferred	☒ Closed	☐ Withdrawn

12. Comments

Date: Fri, 08 Sep 2006 12:45:16 -0400
To: Franklin Hartman <fhartman@mail.wsc.nasa.gov>
From: Keiji Tasaki <Keiji.K.Tasaki@nasa.gov>
Subject: Fwd: TKUP-A RFAs #6 and #11
Cc: Yen.Wong@gsfc.nasa.gov

Hi, Frank.
I accept both. I made a few comments.

Performing preliminary tests through the TDRS channel in advance of the demos will be fine. We just need to anticipate questions, requests, objections, excuses, etc. from the demo contractors, and respond to them strictly, but fairly

Keiji

13. Approval

Yen Wong – Product Design Lead

10/18/06
Date

REQUEST FOR ACTION (RFA)

1. Review Type	2. RFA No.	3. Review Date
TKUP-A Demonstration Requirements Review	278-07	**8/2/06**

4. Title

Modulator equality for all vendor demonstrations

5. Action

How will the TKUP-A demonstration team ensure that modulator characteristics and distortions are equal for all vendor demonstrations? If modulator characteristics and distortions cannot be assured across all vendor modulators, how will this be accounted for in the vendor demo evaluations?

Reference

6. Originator/Organization/Telephone No./E-mail

Wai Fong GSFC/567 301.286.8165 wai.h.fong@nasa.gov

7. Assigned To/Organization/Telephone No./E-mail	Due Date
John Wesdock/ITT/703.668.6332/ John.Wesdock@itt.com	9/29/06

8. Response

See attached response.

9. Response By/Organization/Telephone No./E-mail	Date Prepared
John Wesdock/ITT/703.668.6332/ John.Wesdock@itt.com	

10. Originator Contacted	☐ No	☒ Yes	Date	8/31/06

11. Disposition	☐ Open	☐ Deferred	☒ Closed	☐ Withdrawn

12. Comments

From: Wai Fong <wfong@pop700.gsfc.nasa.gov>
Subject: Re: Reminder on TKUP-A DRR RFAs #7
Date: Mon, 16 Oct 2006 09:54:40 -0400
To: Yen F Wong <yen.f.wong@nasa.gov>

Yen,

I don't have an issue with RFA #7 response.

Wai

13. Approval

Yen Wong – Product Design Lead

10/18/06
Date

RFA #7 Response

The following approach is proposed to ensure vendor demonstration results are interpretable and comparable while still maintaining a cost-effective and practical test approach:

1. Each demonstration vendor will provide their own test modulator during demonstration testing.

2. Prior to demonstration testing, each demonstration vendor will provide a functional block diagram overview of their test modulator.

3. Prior to demonstration testing, each demonstration vendor will provide the top-level characteristics of important components or circuitry. For example, the 3 dB bandwidth of all filters which interact with the data signal should be stated as well as the clock rate of all components.

4. Each test modulator will be recommended to meet the distortion constraints stated in Table 1 shown below.

5. Prior to demonstration testing, each demonstration vendor must provide to NENS a characterization of their modulator distortion performance, i.e., each demonstration vendor must measure, or otherwise determine, the levels of modulator distortions identified in Table 1 and state this measured performance to NENS. Preferably this characterization will be a statement of the measured values for the distortion types stated in Table 1, however, also acceptable would be eye diagrams (for I and Q channel), scatterplots and Error Vector Magnitude (EVM) measurements.

6. NENS will evaluate the vendor modulator functional, performance and implementation characteristics and ensure that any differences in vendor modulator operation or performance are understood and considered in the results interpretation and comparison process. NENS in association with NASA may use analytical and/or simulation techniques to quantify the potential impact of vendor modulator differences on demonstration BER performance. Note that feedback from the receiver to the modulator will be strictly forbidden by the NENS RFP text.

7. Modulator performance noncompliances which cannot be corrected or are too costly or complicated to correct will be accepted and will be evaluated and understood by NENS in association with NASA using analytical and simulation techniques.

8. NENS will utilize the NASA/GSFC Code 567 High-Rate Baseband Modulator (HRBM) to establish baseline coded and uncoded BER performance through the TDRSS KuSAR 225 MHz channel for data rates potentially up to 400 Mb/sec against which all vendor BER performance will be compared. Note that the Code 567 HRBM includes an integrated (8167,7136) LDPC encoder, however, it does not include a TPC-encoding capability. Also note that the modulator can only support data rates potentially up to 400 Mb/sec unless additional funding is provided to increase the data rate to up to 600 Mb/sec.

Table 1. Summary of Modulator Constraints

Parameter	Constraint Value
Symbol Asymmetry (peak) (Note 1)	≤ ±3%
Symbol Jitter (Note 1)	≤ 0.2%
I/Q Symbol Skew (peak) (Note 1)	≤ 3%
Symbol Rise Time (90% of initial state to 90% of final state)	≤ 5%
Gain Imbalance	≤ ±0.25 dB
Phase Imbalance	≤ ±3° (SQPSK) ≤ ±2° (8PSK)
Channel Bandwidth	≥ 2 times maximum channel baud rate (Note 2)

Notes:

1. Both 8-PSK and QPSK physically have I and Q channels that have signal level changes. For 8-PSK, the signal level for an individual I or Q channel can have any one of four possible signal levels at a given moment. For SQPSK, the signal level for an individual I or Q channel can have any one of two possible signal levels at a given moment. For 8-PSK and SQPSK, a channel state symbol is defined as the signal level status of an individual I or Q channel.

2. Baud rate is defined as the rate at which the phase of the carrier wave is changed by the modulating signal.

The rationale for this approach is as follows:

1. As part of building and testing a receiver, the demonstration vendors must build a test modulator. Because of this, it is expected that requiring the demonstration vendors to provide their own modulator will not substantially increase the cost of the demonstration (or, more appropriately, will not reduce the amount of capabilities demonstrated).

2. It is expected that demonstration vendors will feel there exists less risk in using their own modulator rather than integrating yet another device into their test set-up. Note that the demonstration vendor is already interfacing with the WSC EET equipment, integrating in the NASA/GSFC LDPC core (or some device of similar likeness), integrating a third-party TPC encoder chip and potentially integrating in a CCSDS randomizer. The TKUP-A team feels the likelihood of success on test day is increased by allowing the demonstration vendors to operate on and test with the modulator they are most familiar with.

3. The approach includes protections against attempts to include performance-improving techniques in the modulator design which are not desired to be levied on TKUP customer hardware.

4. Demonstration vendors will not want to undermine their own performance by using an inferior test modulator. High quality test modulators are expected to be used and because of this, modulator impact on BER performance is expected to be a secondary effect. Variations in performance among high performance modulators will not be overly apparent in the test results.

5. To some degree, the demonstration effort is intended to assess how competent vendors are working with the new modulation and coding techniques. Providing a modulator which supports the new modulation techniques and coding technique counteracts NENS' attempt to mitigate hardware implementation risk through a demonstration.

6. By requiring all modulators to meet a common set of high fidelity performance requirements, the modulator as a significant driver of BER performance is eliminated. Note that the allowed modulator distortion levels probably contribute less than 0.5 dB to overall BER performance on a coded, generally bandlimited channel.

7. If test modulator performance is poor, this perhaps indicates a lack of technical competence.

8. Modulator performance noncompliances can be accepted and understood using the analysis and simulation techniques already developed under the KaDS and TKUP projects.

REQUEST FOR ACTION (RFA)

1. Review Type	2. RFA No.	3. Review Date
TKUP-A Demonstration Requirements Review	278-08	**8/2/06**

4. Title

Data Randomization

5. Action

Since the demonstration objectives don't include a Randomizer, possible false lock to spurring may occur, as well as other receiver failure possibilities. Consider adding CCSDS randomization to demonstration requirements.

Reference

6. Originator/Organization/Telephone No./E-mail

Wai Fong GSFC/567 301.286.8165 wai.h.fong@nasa.gov

7. Assigned To/Organization/Telephone No./E-mail	Due Date
John Wesdock/ITT/703.668.6332/ John.Wesdock@itt.com	9/29/06

8. Response

See attached response.

9. Response By/Organization/Telephone No./E-mail	Date Prepared
John Wesdock/ITT/703.668.6332/ John.Wesdock@itt.com	8/31/06

10. Originator Contacted	☐ No	☒ Yes	Date	8/31/06

11. Disposition	☐ Open	☐ Deferred	☒ Closed	☐ Withdrawn

12. Comments

> From: Wai Fong [mailto:wfong@pop700.gsfc.nasa.gov]
> Sent: Monday, September 25, 2006 4:43 PM
> To: Wesdock, John -AES; Wai.H.Fong@nasa.gov
> Cc: yen.f.wong@nasa.gov; fhartman@mail.wsc.nasa.gov; Tran, Leonardi -AES
> Subject: RE: TKUP-A DRR RFAs #7 and #8
>
> Yen, John
>
> RFA 008 - I don't have an issue with the response.
>
> Wai

13. Approval

Yen Wong – Product Design Lead

10/18/06
Date

RFA #8 Response

The following approach is proposed to address concerns regarding the randomness of the source data during demonstration testing:

1. The TKUP-A Demonstration RFP text will state that the demonstration source data must be random or random-like. An example of a random-like signal would be an 18-stage shift register PN sequence.

2. The TKUP-A Demonstration RFP text will state the following data source requirements must be met:

    - Minimum channel bit transition density shall be ≥128 randomly distributed bit transitions within any sequence of 512 bits

    - Consecutive channel data bits without a data bit transition shall be ≤64 data bits

3. The TKUP-A Demonstration RFP text will state that a CCSDS data randomizer device exists and is available for use during the demonstration.

The rationale for this approach is as follows:

1. The RFP text can be modified as described above to bring sufficient awareness to the need to use random or nearly-random source data. Mandating a randomizing device be integrated into the test equipment seems like an excessive solution.

2. Demonstration vendors are not expected to use source data which has the potential to undermine BER performance during the demonstration.

3. Existing TDRSS customers are not required to use randomizers, therefore, mandating a randomizer be used during the demonstration is not representative of the actual conditions under which a TKUP-A receiver may be required to operate.

4. There is a desire to keep things simplified in this demonstration. Mandating that a randomizer be used in the demonstration increases the amount of unfamiliar hardware the demonstration vendors must work with and does not appreciably change the transition statistics of a long PN sequence, i.e., the type of data source expected to be used during the demonstrations.

While it is proposed that a randomizer not be mandated for the TKUP-A demonstration, consultation with NASA/GSFC Code 450 will be pursued to determine whether the production receiver specification will include the condition that a data randomizer will always be present in the customer transmitter and whether the receiver should support de-randomization. That is discussions will be initiated to determine whether the SNUG should mandate that TDRSS customers utilize a randomizer and whether the Space Network's support of de-randomization is beneficial.

REQUEST FOR ACTION (RFA)

1. Review Type	2. RFA No.	3. Review Date
TKUP-A Demonstration Requirements Review	278-09	**8/2/06**

4. Title
Connection with ECANS management

5. Action
Ensure that ECANS management and chief engineer are consulted on TKUP-A plans, objectives and results. They will be a major NASA customer for these services.

Reference

6. Originator/Organization/Telephone No./E-mail
Ken Perko GSFC/567 301.286.5936 kenneth.l.perko@nasa.gov

7. Assigned To/Organization/Telephone No./E-mail	*Due Date*
Yen Wong GSFC/567 301-286-7446 Yen.f.wong@nasa.gov	

8. Response
Meeting with ECANS management and chief engineer was held on Sept 6, 2006. An overview on TKUP-A objectives, approach and schedule was presented during the meeting. Adding the JPL R1/2 LDPC code into TKUP-A demonstration was recommended by ECANS. As a result, the TKUP-A RFP demonstration contract has been modified to include ECANS coding as a baseline requirement.

The TKUP-A RFP with ECANS coding requirement has been released on Oct 11, 2006.

The BER performance simulation of the JPL R1/2 LDPC code was performed and results have been incorporated into the TKUP-A demonstration requirements document.

Continued close connection with ECANS management and technical staff is planned during TKUP-A demonstration phase and production phase to ensure that the SN will be prepared to meet ECANS requirements and that as much synergy as possible is obtained with the Ka-Band receive system equipment to be needed by others ECANS ground terminals.

9. Response By/Organization/Telephone No./E-mail	*Date Prepared*
Yen Wong GSFC/567 301-286-7446 Yen.f.wong@nasa.gov	10-11-06

10. Originator Contacted	☐ *No*	☒ *Yes*	*Date*

11. Disposition	☐ *Open*	☐ *Deferred*	☒ *Closed*	☐ *Withdrawn*

12. Comments

Response is accepted by K. Perko on 10/12/2006.

13. Approval

Yen Wong

Yen Wong/ Product Design Lead

10-18-06
Date

REQUEST FOR ACTION (RFA)

1. Review Type	2. RFA No.	3. Review Date
TKUP-A Demonstration Requirements Review	278-10	**8/2/06**

4. Title

Proprietary issues at demo

5. Action

Address final requirements with respect to proprietary aspects of production equipment. If final requirement will preclude proprietary components, vendors should know that and address it in their demo proposals.

Reference

6. Originator/Organization/Telephone No./E-mail

Frank Hartman NENS/WSC 505.527.7363 fhartman@mail.wsc.nasa.gov

7. Assigned To/Organization/Telephone No./E-mail	Due Date
Yen Wong Code 567 301.286.7446 yen.f.wong@nasa.gov	

8. Response

Due to the long period of expected operation and maintenance of the operational modem (life cycle of the production modem is expected to be on the order of 15 years), NASA would like the vendor to consider a timed conversion of any proprietary intellectual property to NASA ownership. While there is no need that the proprietary issue to be a requirement during the prototype demonstration phase, it is recommended to address this in the demonstration RFP requesting the vendors to propose a plan for long-term maintenance including delivery of proprietary property(for instance, proprietary firmware) to HTSI (or its successor at WSC). A cost estimate is expected to be included in the basis of cost for the proposal. It will provide NASA and HTSI with useful information to develop the proprietary requirements for the production equipment procurement.

9. Response By/Organization/Telephone No./E-mail	Date Prepared
Yen Wong Code 567 301.286.7446 yen.f.wong@nasa.gov	

10. Originator Contacted	☐ No	☒ Yes	Date	10/3/06

11. Disposition	☐ Open	☐ Deferred	☒ Closed	☐ Withdrawn

12. Comments

Date: Tue, 03 Oct 2006 15:07:28 -0600
To: Yen F Wong <yen.f.wong@nasa.gov>
From: Franklin Hartman <fhartman@mail.wsc.nasa.gov>
Subject: Re: RFA #10

Yen,
I'm fine with this.
Frank

13. Approval

Yen Wong – Product Design Lead

10/18/06
Date

REQUEST FOR ACTION (RFA)

1. Review Type	2. RFA No.	3. Review Date
TKUP-A Demonstration Requirements Review	278-11	**8/2/06**

4. Title

Method of payment for demonstrations.

5. Action

Ensure that NENS clearly describes the method of payment for different Levels (Levels 0 through 3) of the demonstrations that a given vendor may propose. This is to avoid a situation where a vendor proposes, say Level 3, but fails to produce a prototype system that demonstrates Level 3 capability. In this case, the vendor should not be paid for work that was promised, but not delivered.

Reference

6. Originator/Organization/Telephone No./E-mail

Keiji Tasaki GSFC/452 301.286.9370 keiji.k.tasaki@nasa.gov

7. Assigned To/Organization/Telephone No./E-mail	Due Date
Franklin Hartman / WSC / 505.527.7363 / fhartman@mail.wsc.nasa.gov	8/10/2006

8. Response

Demonstration contract payment will not be based on level achieved; in all likelihood, different vendors will be eligible for the same level of funding for different levels of capability.

Suppliers will be required to establish measurable milestones for payment as part of their proposals. In negotiating contract details, NENS will ensure that these milestones and associated payments adequately protect the value of services provided for all payments made.

9. Response By/Organization/Telephone No./E-mail	Date Prepared
Franklin Hartman / WSC / 505.527.7363 / fhartman@mail.wsc.nasa.gov	8/30/2006

10. Originator Contacted	☐ No	☒ Yes	Date	9/1/06
11. Disposition	☐ Open	☐ Deferred	☒ Closed	☐ Withdrawn

12. Comments

Date: Fri, 08 Sep 2006 12:45:16 -0400
To: Franklin Hartman <fhartman@mail.wsc.nasa.gov>
From: Keiji Tasaki <Keiji.K.Tasaki@nasa.gov>
X-ASG-Orig-Subj: Fwd: TKUP-A RFAs #6 and #11
Subject: Fwd: TKUP-A RFAs #6 and #11
Cc: Yen.Wong@gsfc.nasa.gov

Hi, Frank.
I accept both. I made a few comments.
The use of measurable milestone, i.e., Earned Value technique-like method, will be fine. NENS should assure that actual progress is being made throughout the demo development phase.

Keiji

13. Approval

Yen Wong – Product Design Lead

10/18/06
Date